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EVALUATION OF HARDNESS AND CORROSSION BEHAVIOUR OF Al 7075/TiB_2/Cr_2O_3 COMPOSITE

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ABSTRACT

Aluminium composite is an attractive material for using in corrossive environment. Many studies have been conducted on corrossion rate in Aluminium composites. In this work Aluminium 7075 composite is reinforced with TiB_2 and Cr_2O_3 with different weight perentage of reinforcements. From the results it is understood that the density of the composite increases with more addition of reinforcements to the matrix. The uniform immersion test (ASTM–G31) in 90 ml of HCl was conducted. It was found that there is an increase in corrossion resistance when the reinforcements were added.

KEYWORDS: Aluminium Composite, Uniform Immersion Test & Corrossion

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Original Article

INTRODUCTION

Aluminium metal is a popular material in many of the engineering applications like Aerospace application, Automobile applications etc. Nowadays the Aluminium alloys are slowly replaced with composite materials. The composite materials shows an improved material properties when compared to Aluminium alloys.

A study made by Gu et al. [13] shows that when Aluminium is reinforced with carbon fibers its corrossion rate decreases in distilled water. Bodunrin et al. [6] reported that Aluminium when reinforced with SiC, Gr and Al_2O_3shows a decrease in corrossioj rate when compared with parent alloy. A study made by Cheng et al. [8] shows that the addition of SiC in Aluminium 7075 alloy increases the corrossion rate. Bobić et al. [5] reported that the presence of Mica and Alumni in the matrix elevate the corrossion resistance of 356 alloy. Bobić et al. [4] made a study that the addition of graphite, glass and zircon particles improves the corrossion resistance in Zinc alloy metal matrix composite. Coleman et al. [9] reported that the corrossion rate for Al-7Si-0.5Mg alloy can be reduced with the addition of carbon fiber. El-Aziz et al. [10] reported that the presence of Al_2O_3particle will decrease the corrossion rate in Al-Si alloy material composites. Abbass et al. [1] made a study on Aluminium 6061 composite and found that the addition of SiC will reduce the corrossion resistance rate significantly. Ahmad et al. [2] made a comparitive study and found that corrossion rate of MMC's decreases with exposure in immersion test and pitting potential decreased with increase in volume fraction of SiC composites. Hihara and Latanision [15] reported that the presence of graphite fiber, SiC and TiB_2improve the corrossion resistance in Aluminium 6061 metal matrix composites. A study made by Wielage et al. [19] shows that the corrossion rate can be improved further by adding diamond like carbon coated carbon fiber in Aluminium metal matrix composites. Cai et al. [7] reported that carbon fiber can increase the corrossion resistance in Aluminium composites when tested in artificial sea water. Sherif et al. [18] made a study and conclude that the corrossion rate increases with the addition of Graphite in pure

Aluminium composites. Saravanan et al. [17] reported that the addition of cenosphere will reduce corrossion rate for Alumnium 6063 metal matrix composites. Falcon et al. [12] made a study that the presence of TiC particles in Mg-Aluminium alloy composites will increase the corrossion resistance. Elcicek et al. [11] reported that addition of AlB_2in Al-Cu alloy metal matrix will reduce the corrossion rate of the composites. The presence of α-Al amorphous structures in Aluminium matrix surface will reduce the corrossion rate which was reported by [16]. When Silicon Carbide patriculates were used as reinforcements in 5A06 Aluminium matrix composite the overall corrossion rate decreases. This study was made by Aziz and Zhang [3]. The corrossion rate for Aluminium composite can be reduced by adding B_4C as reinforcement. This study was made by Han et al. [14]. When red mud was added to Aluminium 6061 metal matrix its overall corrossion rate decrease which was reported by Zucchi et al. [20].

From the above literatures it is clear that much work is not done on corrossion study in Al7075-TiB_2, Cr_2O_3 composites. In this present work evaluation of corrossion rate, strength and density have been carried out. Stir Casting method was adopted for fabricating the composite since it is an efficient manufacturing method for preparing composites.

EXPERIMENTAL METHOD

Stir casting method was selected for manufacturing composite. It is an efficient and economical method of manufacturing composites. The density of Aluminium 7075 is 2.65 g/cc. The density of TiB_2 and Cr_2O_3 are 4.52 g/cc and 5.22 g/cc respectively. Three hybrid composites were prepared. The weight percentage of TiB_2 selected were 10 % and maintained as constant. The weight percentage of Cr_2O_3 was varied as 4%, 6% and 8%.

Table 1: Weight Percentage of Reinforcements

Samples	TiB_2 Weight %	Cr_2O_3 Weight %
Sample 1	10 %	4 %
Sample 2	10 %	6 %
Sample 3	10 %	8 %

The Aluminium alloy was melted when it was heated to a temperature of 440^oC. At this temperature there is a chance of oxidation. So in order to prevent oxidation degassing was done using nitrogen for a time period of 4 minutes. The reinforcements TiB_2 and Cr_2O_3 were also preheated. The Aluminium 7075 was again heated to 900^oC. At this temperature stirring was done at 250-450 rpm. The stirring was continued for approximately 2 minutes and during this time the preheated reinforcements were added to the liquid metal. The stirring was continued for another 2 minutes. This was done to ensure uniform distribution of reinforcements in the material. The molten metal was poured to the prepared metallic mould. After pouring it was allowed to solidify at room temperature. After solidification the workpiece of required dimension was removed from the metallic mould.

SEM IMAGE ANALYSIS

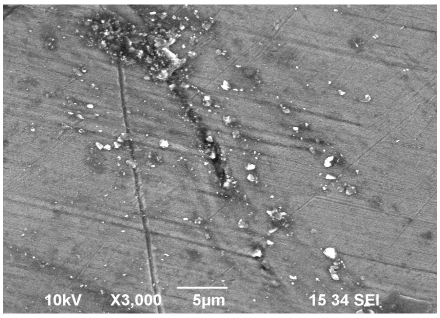

Figure 1: SEM Image of Sample 1

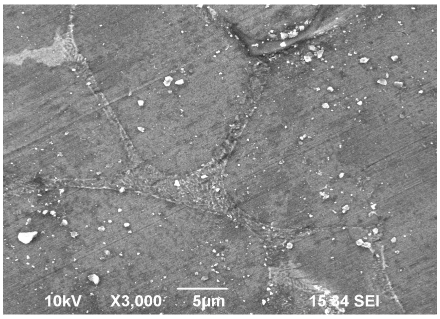

Figure 2: SEM Image of Sample 2

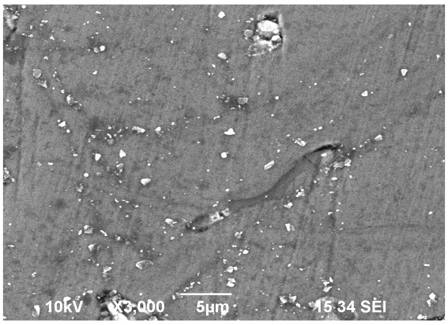

Figure 3: SEM Image of Sample 3

From the SEM image it can be clearly seen that the particles are uniformly distributed in Aluminium matrix. The presence of the materials can be ensured from EDX pattern. The images shows that the particles added during the manufacturing are present in the matrix. As the weight percentage of Cr_2O_3 was more in specimen 2 the EDX pattern was slighlty varied. Similar variation can be seen in EDX pattern for specimen 3 also. From the below figures it is clear that good mechanical bonding was achieved between the matrix and reinforcements. Since mixing of reinforcements was made on semi solid state of Aluminium, it ensures the proper mixing of reinforcements in Aluminium matrix. TiB_2 and Cr_2O_3 provide sufficient wettability with present matrix and this ensures good mechanical bonding with the matrix. In figure 1 only lesser particles can be see. But in figure 2 and figure 3 more paticles can be seen. This is due to addition of more quantity of Cr_2O_3 particles in the Aluminium matrix. Since stirring was continued even after mixing reinforcements which ensures satisfactory distribution of reinforcements in Aluminium matrix.

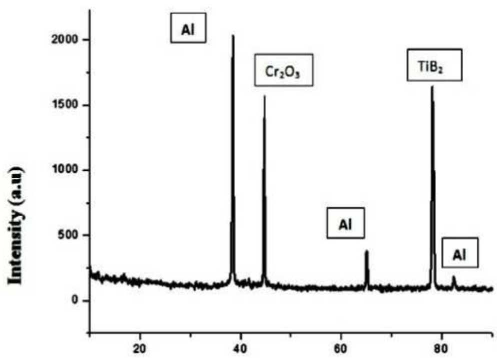

Figure 4: XRD image of Specimen 1

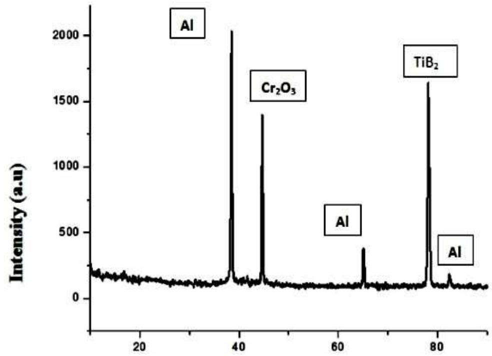

Figure 5: XRD Image of Specimen 2

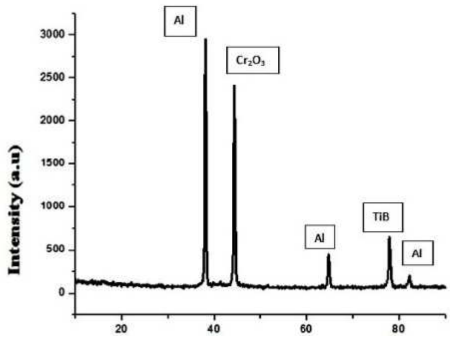

Figure 6: XRD image of Specimen 3

HARDNESS TESTING

For checking Vickers Hardness ASTME10 standard was followed. The testing was conducted and hardness value was noted. The results shows that the hardness value was significantly increased when percentage of Cr_2O_3 in Aluminium matrix was increased. The density of the specimens was also calculated. From the results it was clear that the density of the composites was higher than the parent Aluminium alloy. The density of the composite increases with increase in weight percentage of Cr_2O_3. Thus increase in density is due to the fact that more reinforced were filled in specimen porosity. thus further increase in weight of the component.

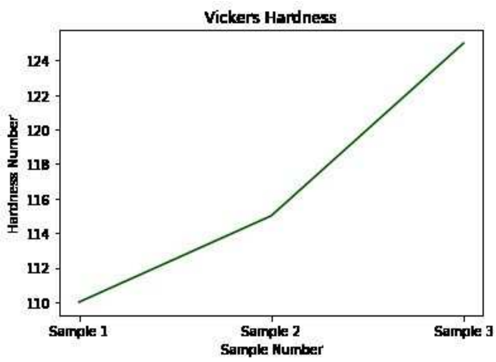

Figure 7: Hardess Test Values

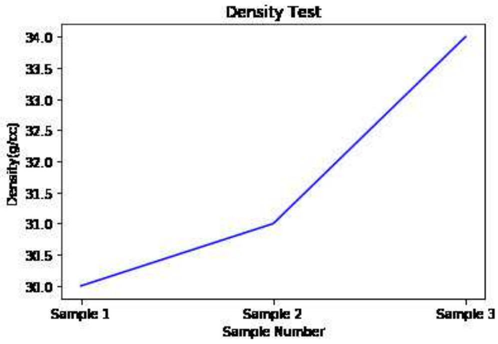

Figure 8: Density Test Values

CORROSSION ANALYSIS

For analysing corrossion rate, the specimens are immersed in diluted 90 ml HCl solution. HCl was preferred over NaCl solution because the rate of corrossion will be more in HCl solution when compared to NaCl solution. Results shoea that there is a decrease in corrossion rate in the hybrid composites. From figure 9 it can be observed that the corrossion rate gradually decreases with the increase in weight perentage of Cr_2O_3. As the weight percentage of reinforcements were increased more pores in the parent material were filled with reinforcements. This in turn results in a decrease on the corrossion rate. Since more voids were filled this reduces lesser places for corrossion to start in the composite. The calculation for corrossion rate in mm/yr is as follows.

$c = \frac{87.6 \times W}{\rho \times A \times t}$ ρ = density in g/cm^3

W = loss of weight in mg

A = Area in cm^2

t = time period in hours

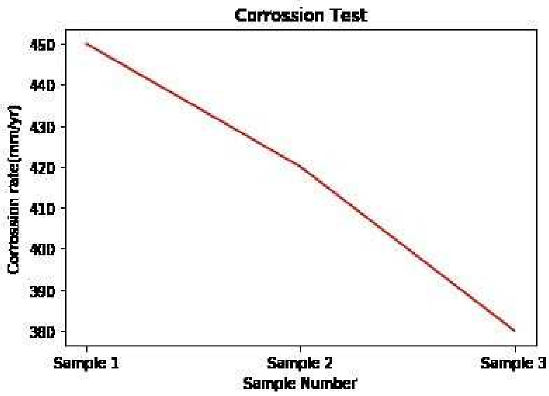

Figure 9: Corrossion Test Values

There are many factors that influence corrossion rate. Some of the factors are reinforcement shape, type, size, processing techniques and environmental factors. If the processing techniques for manufacturing composite materials are changed this can change the corrossion rate. There should be proper bonding between matrix and reinforcements. The strong bonding of matrix with reinforcement can lead to higher corrossion resistance. The increase in corrossion resistance

may also due to good bonding between parent material and reinforcements. If more reinforcement particles are bonded with parent material lesser will be corrossion rate. Corrossion rate decreases with weight percentage of reinforcements.

CONCLUSIONS

The present work can be concluded as follows

- The metal matrix hybrid composites were fabricated successfully using stirr casting technique.
- SEM image shows the dispersion of reinforcements in matrix phase were fairly uniform.
- The hardness of the composite increase when more Cr_2O_3 is added to the matrix.
- The corrossion resistance increase with increase in weight percentage of Cr_2O_3.

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